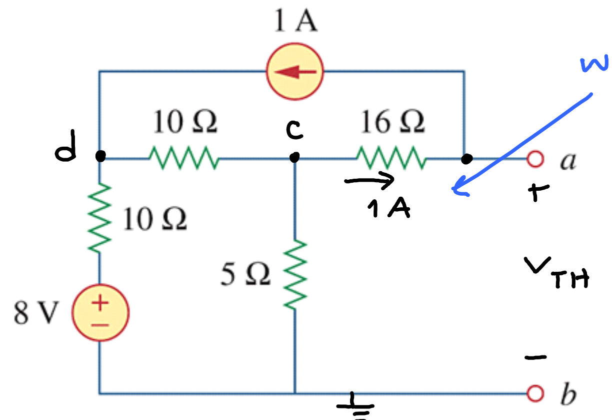
HW5

Thursday, December 10, 2009
3:24 PM

4.39 First we find V_{TH}



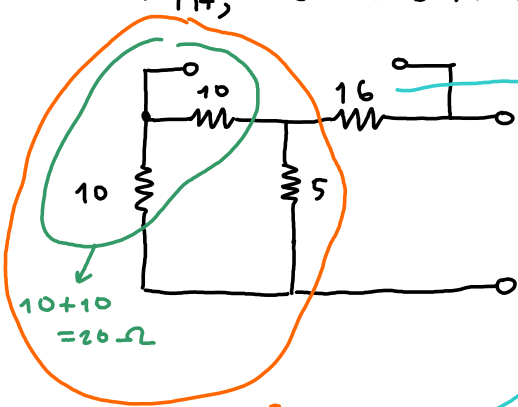
We know right away that the current through 16 Ω resistor is 1 A by KCL at "c".

Use nodal analysis : Maple

$$\left.\begin{aligned} 1 + \frac{V_c - V_d}{10} + \frac{V_c}{5} &= 0 \\ \frac{V_d - 8}{10} + \frac{V_d - V_c}{10} - 1 &= 0 \end{aligned}\right\} \Rightarrow \quad V_c = -\frac{2}{5}, \quad V_d = \frac{44}{5}$$

$$V_a = V_c - 16 \times 1 = -\frac{2}{5} - 16 = -16.4\ V = V_{TH}$$

For R_{TH}, we deactivate all the sources:

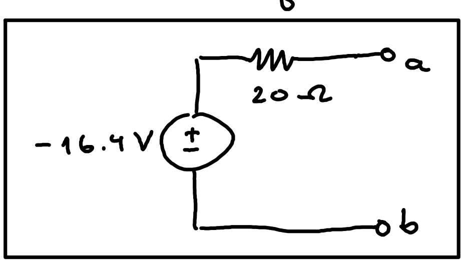


$10 + 10 = 20\,\Omega$

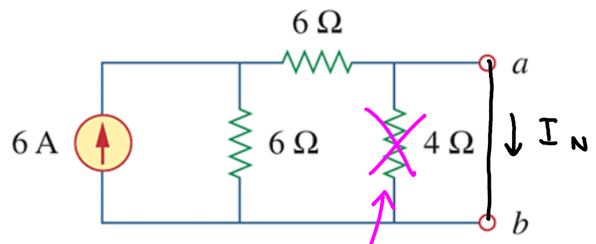
$\frac{20 \times 5}{20+5} = 4\,\Omega$

$R_{TH} = 4 + 16 = 20\,\Omega$

The Thevenin equivalent at terminal a-b is



4.45 I_N = short-circuit current

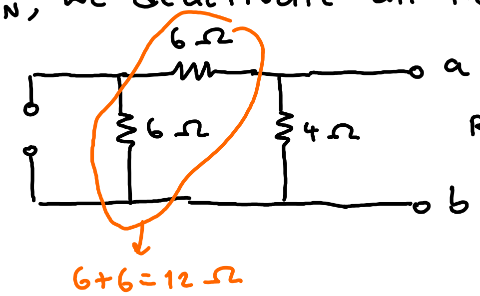


The 4 Ω resistor is gone because it is short out.

By the current divider formula, the 6 A from the current source is split equally between the two 6 Ω resistors.

Hence, $I_N = 3\,A$.

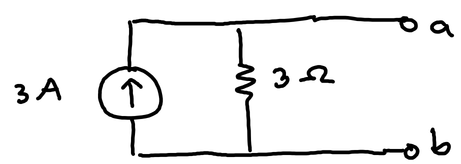
For R_N, we deactivate all the sources:



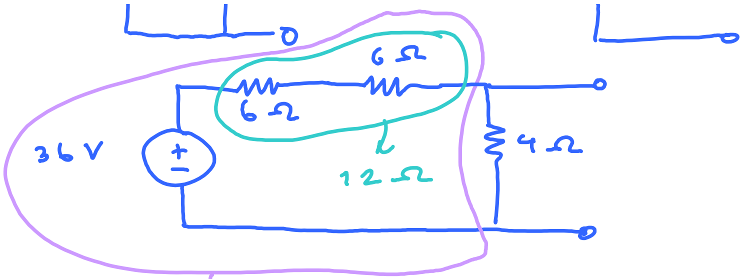
$R_N = 12 // 4$

$= \frac{12 \times 4}{12+4} = 3\ \Omega$

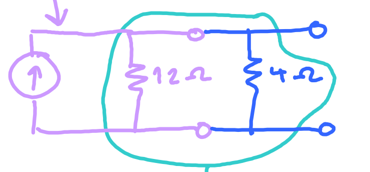
The Norton equivalent is given by



Alternatively, we may use source transformation

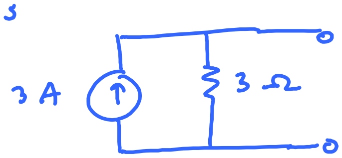


$\frac{36}{12} = 3\text{ A}$



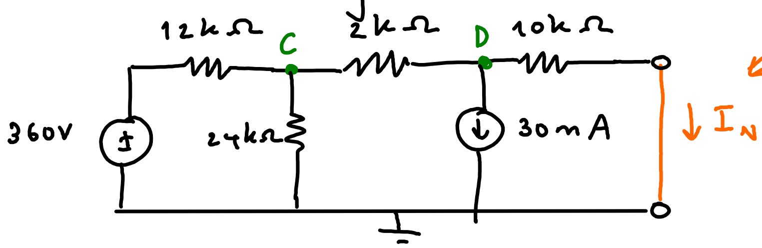
$12 // 4 = 3\ \Omega$

This gives



which is the same as what we got from Norton's theorem above.

(4.56) Note that the question specifies that we have to use the Norton theorem. Hence we will first need to find Norton equivalent of the following circuit



Find I_N, the short-circuit current.

Use Nodal analysis:

At c: $$\frac{V_c - 360}{12k} + \frac{V_c}{24k} + \frac{V_c - V_D}{2k} = 0$$

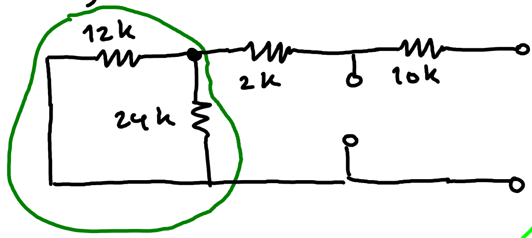
$$30m + \frac{V_D - V_c}{2k} + \frac{V_D}{10k} = 0$$

$\Rightarrow$ $V_c = 24$ V, $V_D = -30$ V

Note that if I multiply these two equation by 1,000, the m and k will majically disappear. So, I don't really hae to care about them.

$$I_N = \frac{V_D}{10k} = \frac{-30}{10k} = -3\text{ mA}$$

For R_N, we deactivate all the source and get

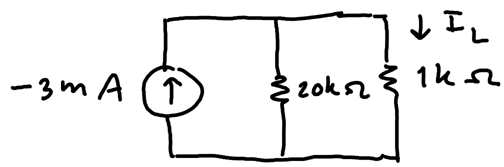


$R_{TH} = 8+2+10$
$= 20\,k\Omega$

$12k \,//\, 24k$

$= \dfrac{\cancel{12}^{1} \times 24}{\cancel{12} + \cancel{24}_{2}}\,k = 8k$

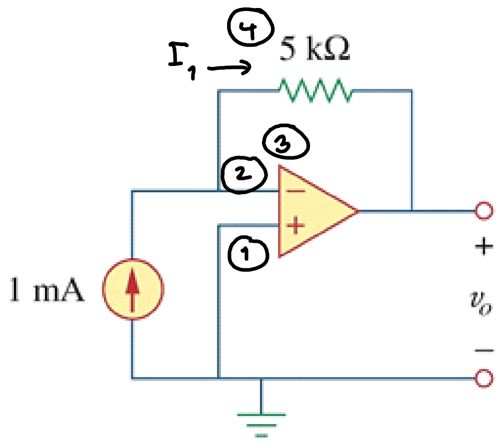
Now, we connect the Norton equivalent back to the load resistor:



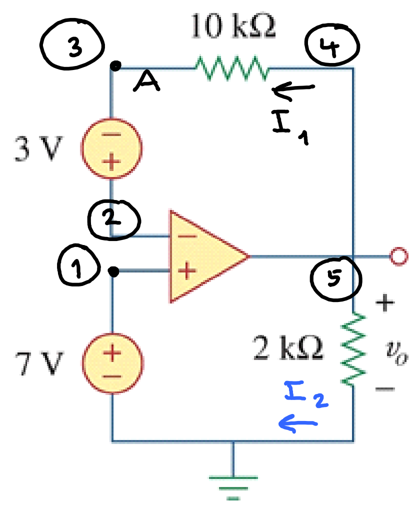
The current I_L is $-3m \times \dfrac{\frac{1}{1k}}{\frac{1}{1k} + \frac{1}{20k}} = -3 \times \dfrac{20}{21}\,mA$

$V_o = I_L \times R_L = -3\cancel{m} \times \dfrac{20}{21} \times 1\cancel{k} = \boxed{-\dfrac{60}{21}\,V \approx -2.86\,V}$

5.8



(a)



(b)

① $v_+ = 0\,V$ because it is connected to the ground.

② $v_- = v_+ = 0\,V$ by Rule #2

③ $i_- = 0\,A$ by Rule #1

④ $I_1 = 1\,mA$ because $i_- = 0$.

⑤ $v_o = v_- - I_1 \times 5k$

$= 0 - 1mA \times 5k\Omega$

$= \boxed{-5\,V}$

① $v_+ = 7V$.

② $v_- = v_+ = 7V$ by Rule #2.

③ $v_- - v_A = 3V$

$v_A = v_- - 3V$

$= 7V - 3V$

$= 4V$

④ $I_1 = i_- = 0$

by Rule #1

⑤ $v_o = v_A + I_1 \times 10k$

$= v_A + 0 = v_A$

$= \boxed{4\,V}$

Note: It is tempting to say

$I_2 \overset{?}{=} i_+ = 0$ by

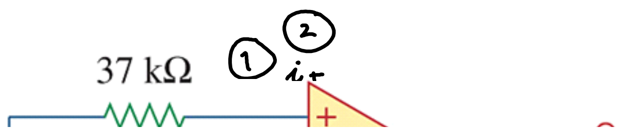
Rule #1 and hence

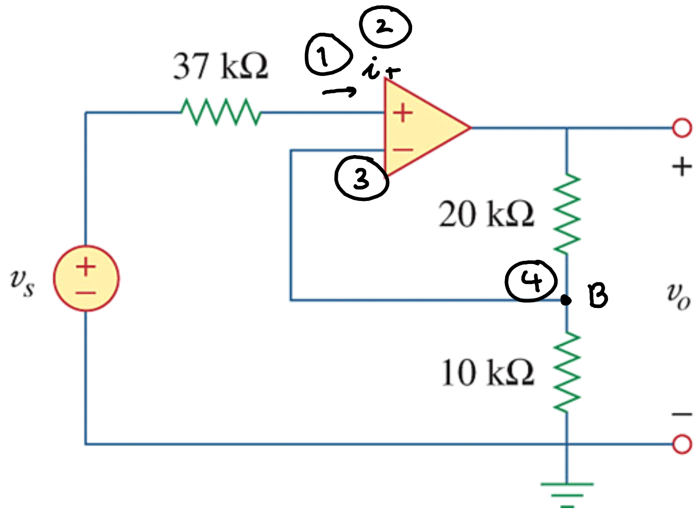
$v_o = 0 + I_2 \times 2k\Omega$

$= 0 + 0 = 0$

This is not true because there could be some current flows into the ground!!

5.10





1. $i_+ = 0$ by Rule #1
2. $v_+ = v_s - i_+ \times 37\,k\Omega = v_s - 0 = v_s$
3. $v_- = v_+ = v_s$ by Rule #2
4. KCL at B gives

$$\frac{v_B - v_o}{20k} + \underbrace{\cancel{i_-}}_{0} + \frac{v_B}{10k} = 0$$

$v_B = v_- = v_s$ by 3

by Rule #1

$$\frac{v_B}{20\cancel{k}} + \frac{v_B}{10\cancel{k}} = \frac{v_o}{20\cancel{k}}$$

$$v_B + 2v_B = v_o$$

$$v_B = \frac{1}{3} v_o$$

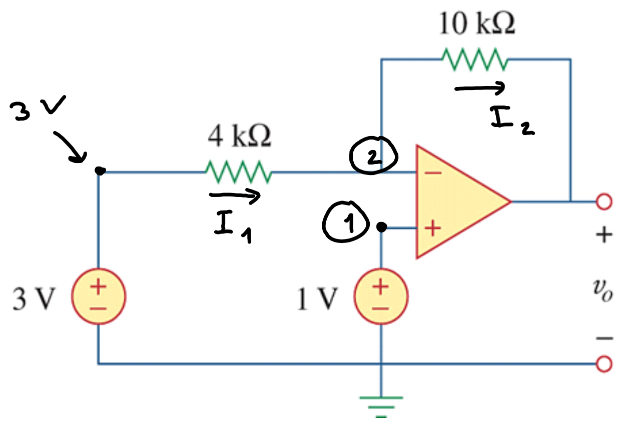
$$\therefore \quad v_s = \frac{1}{3} v_o$$

$$\frac{v_o}{v_s} = 3$$

Alternatively, because $i_- = 0$, the relationship between v_B and v_o is given by voltage divider formula

$$v_B = \frac{10k}{20k + 10k} v_o$$

5.21



1 $v_+ = 1V$

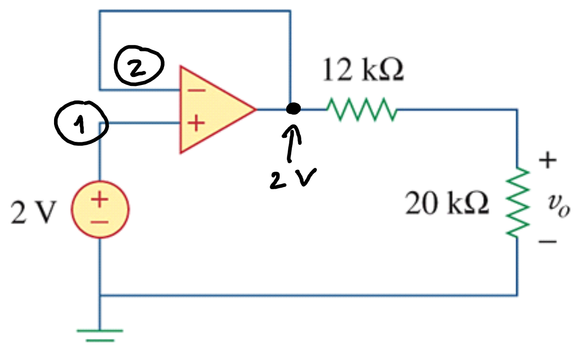
2 $v_- = v_+ = 1V$

3 $I_1 = \frac{3 - V_-}{4k} = \frac{3-1}{4k} = \frac{1}{2} mA$

4 $I_2 = I_1$ because $i_- = 0$ by Rule # 1.

5 $v_o = v_- - I_2 \times 10k = 1 - \frac{1}{\cancel{2}} m \times \overset{5}{\cancel{10}} k = \boxed{-4\ V}$

5.25



1 $v_+ = 2V$

2 $v_- = v_+ = 2V$ by Rule # 2

3 By voltage divider formula,

$$v_o = \frac{20k}{12k + 20k} \times 2V = \frac{20}{32} \times 2 = \frac{40}{32} \boxed{= \frac{5}{4} V = 1.25\ V}$$